

Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11) **EP 1 018 777 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
12.07.2000 Bulletin 2000/28

(51) Int. Cl.<sup>7</sup>: **H01Q 1/24**, **H01Q 9/04**,  
**H01Q 5/00**

(21) Application number: **99310035.3**

(22) Date of filing: **10.12.1999**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU**  
**MC NL PT SE**  
Designated Extension States:  
**AL LT LV MK RO SI**

(30) Priority: **22.12.1998 GB 9828364**  
**23.12.1998 GB 9828533**

(71) Applicant:  
**NOKIA MOBILE PHONES LTD.**  
**02150 Espoo (FI)**

(72) Inventor: **Geeraert, Francis**  
**2500 Valby (DK)**

(74) Representative:  
**Jeffery, Kendra Louise et al**  
**Nokia IPR Department,**  
**Nokia House,**  
**Summit Avenue**  
**Farnborough, Hampshire GU14 0NG (GB)**

(54) **Dual band antenna for a hand portable telephone and a corresponding hand portable telephone**

(57) An antenna device (40) has a first metallic layer (41) acting as resonator plane and defining at least two radiating elements (48,49) separated by a first slit (46), and a second metallic layer (24) arranged substantially in parallel with the first metallic layer (41) and acting as ground plane for the antenna device (40). Feeding means are connected to said first (41) and the second metallic layer (24) for feeding an RF signal to the antenna device (40), said feeding means includes a feeding point (42) in the first metallic layer (41). The first metallic layer (41) is provided with a second slit (47) extending from said first slit (46) with the feeding point (42) placed on a metallized tongue (45) between the first (46) and the second slit (47), whereby surface currents have to pass around the tips (53) of the slits (46,47) towards the radiating elements (48,49). Capacitive couplings (58,54) are used for tuning the resonance frequencies of the radiating elements (49,49). The antenna device (40) is arranged on a dual-band portable telephone hand set (1) being preferably adapted for communication via a cellular network (GSM 900MHz and GSM 1800MHz), but could have been designed for a cordless network as well.

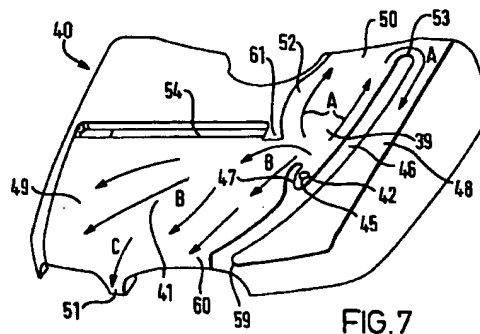


FIG. 7

EP 1 018 777 A2

## Description

[0001] The invention relates to a dual band antenna for a handset. Such an antenna includes a metallic plate or layer acting as ground plane for the antenna, a resonator plate or layer acting as radiating element(s), and a feeding point supplying the signal to the antenna. When the ground plane and the resonator plane are electrically short-circuited the feeding point will be placed in a position where the antenna is matched to the RF output of the handset. Such antennas are known as Planar Inverted F-Antennas (PIFA).

[0002] Until a few years ago all phones for cellular communication were equipped with an extendable antenna element, as known from e.g. the phone sold under the tradename Nokia 2110™. Later on this extendable antenna element was substituted by an external helix antenna, as known from e.g. the phone sold under the tradename Nokia 6110™. Recently the applicant has launched a phone sold under the tradename Nokia 8810™ and this phone includes an internal antenna based on the PIFA concept. The antenna is a so-called single band antenna and the present version it is adapted for GSM in the 900 MHz band (uplink 890-915 MHz and downlink 935-960 MHz). The antenna element will have an electrical length corresponding to a quarter wavelength and by placing a dielectric material between the ground and the resonator plane the overall physical dimensions are reduced. The overall dimensions of the PIFA are reduced to 32 x 20 x 4 mm.

[0003] WO 95/24746 describes an internal antenna having a dielectric body coated with a metallic layer on two substantially parallel surfaces. This antenna is a single band antenna for the GSM 900 MHz band only. Basically a plastic body is moulded and coated with metal. Afterwards a pattern is created in the metallic layer by removing parts of the coated surfaces by milling. This concept has been used in the phone marketed by Hagenuk under the tradename Global Handy™.

[0004] US 5.764.190 describes a capacity loaded PIFA according to which an extra plate is interposed in between the ground plane and the radiating element. This requires that a two-shot moulding process be used in addition to several coating processes.

[0005] A letter by C.R. Rowell and R.D. Murch, "A Compact PIFA suitable for dual frequency 900/1800MHz operation", is published in IEEE Transactions on Antennas and Propagation, April 1998, Volume 46, Number 4. This letter is written by the inventors mentioned in US 5.764.190, and describes further improvement of the three layered antenna concept. The improvement includes providing of a longitudinal slit in the resonator layer in order to obtain two radiating elements. The RF signal is fed to the radiating elements via the intermediate plate.

[0006] A letter by Z. D. Lui and P. S. Hall, "Dual-Frequency Planar Inverted-F Antenna", is published in IEEE Transactions on Antennas and Propagation, Octo-

ber 1997, Volume 45, Number 10. This letter describes a number of solutions - one of these having a rectangular patch for the 900 MHz band. This patch is provided with an L-shaped slot separating one quarter of the 900 MHz band for acting as resonating element in 1800 MHz band. The two resonating elements are interconnected in the bottom of the slot the common feeding point is provided in this interconnection. Furthermore the two resonating elements are shortened in this interconnection by means of a number of shorting pins. Hereby the coupling between the two radiating elements is reduced.

[0007] An object of the invention is to provide a dual band antenna for a handset having a form that can be integrated into the per se known type of handset cabinets.

[0008] This purpose is obtained by an antenna device having a first metallic layer acting as resonator plane and defining at least two radiating elements separated by a first slit, a second metallic layer arranged substantially in parallel with the first metallic layer and acting as ground plane for the antenna device, feeding means connected to said first and the second metallic layer for feeding an RF signal to the antenna device, said feeding means includes a feeding point in the first metallic layer, and said first metallic layer is provided with a second slit extending from said first slit with the feeding point placed on a metallized tongue between the first and the second slit, whereby surface currents have to pass around the tips of the slits towards the radiating elements. Hereby the antenna device may be provided as a dielectric body having the resonator layer provided as a metallic coating. The dielectric body may then be snapped onto a metallic shield and uses this as ground plane.

[0009] The currents are flowing from the metallized tongue toward the two radiating elements, and a cut (defining a neck of the path) is used to separate the current on the two resonating elements. Capacitive couplings are used for tuning the resonance frequencies of the radiating elements.

[0010] The one or more capacitive couplings are provided as a metallic coating extending perpendicular to said first and second metallic layers. Actually these couplers are provided as metallic coating on side and end walls of a dielectric body also carrying the radiating elements. In the preferred embodiment the couplers are terminated at a short distance from the ground plane.

[0011] The antenna device according to the preferred embodiment of the invention the dielectric body is provided by an injection moulding process including two shots. The material used in one of the two injection moulding shots is a resin repelling metal in a subsequent coating process, while the material used in the second shot is a resin to which metal in the subsequent coating process adheres.

[0012] According to the preferred embodiment the dielectric body is provided with coupling means for

establishing a releasable interconnection with a separate metal body acting as the second metallic layer of the device. Preferably the antenna body is snapped onto the shield of the phone.

[0013] By providing the antenna body with feeding means includes a bore through the dielectric body as a connection via connecting the first metallic layer to a connection pad on the rear side of the dielectric body, the feed may be established directly from the PCB to the antenna by means of a resilient spring connector mounted on the PCB.

[0014] The invention is furthermore related to a phone equipped with such an antenna.

Fig. 1 schematically illustrates a preferred embodiment of a hand portable phone according to the invention.

Fig. 2 schematically shows the essential parts of a telephone for communication with a cellular or cordless network.

Fig. 3 shows in details the antenna feeding concept in cross-section.

Fig. 4 shows in perspective the antenna body and the metal shield of a phone prior to assembly.

Fig. 5 shows in plan view of the antenna body and the metal shield when assembled.

Fig. 6 shows in perspective view of the antenna body seen from below.

Fig. 7 shows in perspective view of the antenna body seen from above.

Fig. 8 shows a first alternative embodiment based on the antenna body shown in fig. 6 and 7.

Fig. 9 shows a second alternative embodiment based on the antenna body shown in fig. 6 and 7.

Fig. 10 shows a third alternative embodiment based on the antenna body shown in fig. 6 and 7.

Fig. 11 illustrates the two shot mould process for manufacturing the antenna according to the invention.

Fig. 12 and 13 illustrates the radiation pattern for the 900 MHz band and 1800 MHz band, respectively.

Fig. 14 (a) and (b) illustrates the preferred steps for performing the injection moulding of the antenna according to the antenna.

[0015] Fig. 1 shows a preferred embodiment of a phone according to the invention, and it will be seen that the phone, which is generally designated by 1, comprises a user interface having a keypad 2, a display 3, an on/off button 4, a speaker 5, and a microphone 6 (only openings are shown). The phone 1 according to the preferred embodiment is adapted for communication via a cellular network, but could have been designed for a cordless network as well.

[0016] According to the preferred embodiment the keypad 2 has a first group 7 of keys as alphanumeric keys, two soft keys 8, two call handling keys 9, and a navigation key 10. The present functionality of the soft keys 8 is shown in separate fields in the display 3 just above the keys 8, and the call handling keys 9 are used for establishing a call or a conference call, terminating a call or rejecting an incoming call.

[0017] Fig. 2 schematically shows the most important parts of a preferred embodiment of the phone, said parts being essential to the understanding of the invention. The preferred embodiment of the phone of the invention is adapted for use in connection with the GSM 900MHz and GSM 1800 MHz network, but, of course, the invention may also be applied in connection with other phone networks. The processor 18 controls the communication with the network via the transmitter/receiver circuit 19 and an antenna 20 that will be discussed in details below.

[0018] The microphone 6 transforms the user's speech into the analog signals formed thereby are A/D converted in an A/D converter (not shown) before the speech is encoded in an audio part 14. The encoded speech signal is transferred to the processor 18, which e.g. supports the GSM terminal software. The processor 18 also forms the interface to the peripheral units of the apparatus, including a RAM memory 17a and a Flash ROM memory 17b, a SIM card 16, the display 3 and the keypad 2 (as well as data, power supply, etc.). The audio part 14 speech-decodes the signal, which is transferred from the processor 18 to the earpiece 5 via a D/A converter (not shown).

#### The antenna structure.

[0019] As seen from fig. 3, 4 and 5 the preferred embodiment of the antenna device according to the invention comprises two basic parts - a shield 24 acting as ground plane for the antenna and a dielectric body 40 coated with a metallic pattern 41 where the latter acts as resonator plane. Printed Circuit Board (PCB) 21 carries a plurality of not-shown electric components, and the shield 24 is used as a per se known EMC shielding can for these components. The shield 24 is connected along its periphery to the ground of the PCB 21 and the shield 24 is therefore well suited as ground plane for the antenna. A resilient metallic leg 23 of a connector 22 is soldered onto the PCB 21 and connects a not shown RX/TX path on the PCB 21 to the antenna

body part 40 via connection pin 43 having an internal metallised via 42 coherent with the metallic pattern 41.

[0020] The antenna element will be positioned in the upper rear part of the phone.

[0021] As seen from fig. 4 the shield 24 has a number of flanges 25 for guiding the shield relative to the cover of the phone. The shield 24 is secured to the PCB 21 by means of screws or the like passing through the holes 30. The shield 24 is furthermore provided with a punch out 26 for a not shown SIM card connector. The SIM card is placed against the edges of the punch out 26 and secured in this position by not shown locking means. In the top of the shield 24 there is provided a plane area 27 acting as ground plane for the antenna, and this area is also provided with a punch out 29 through which the antenna connector 22 extends. Furthermore the plane area 27 has two resilient spring tongues 28 used for improving the grounding of the antenna along one side (the topside) of the antenna body 40. The shield 24 is formed with a step 28 reducing the distance between the ground plane and the resonator plane in this area.

[0022] In fig. 6 and 7 the antenna body 40 is shown, and from top view (fig. 7) it is seen that the feeding point 42 of the antenna is positioned on the tip of a tongue 45 of the metallic pattern. The feeding point 42 is provided as a plated via coming from the rear side of the antenna body 40 and transferring the RF signal between the PCB 21 and the resonator elements of the antenna. A metal island 44 surrounds the via on the top of the connection pin 43. The shape of the tip of the tongue 45 corresponds to the form of the metal island 44 in order to ease the production.

[0023] The tongue 45 on the metallic pattern 41 is defined in between a main slit 46 and a minor slit 47 branching from the mid one third of the main slit 46. The length of the main slit 46, and in particular the circumference, has a substantial influence on the resonance frequency of the two radiating elements 48 and 49 of the antenna. The tongue 45 is coherent with the two radiating elements 48 and 49 via a common frequency part 39. The two radiating elements 48 and 49 are according to the preferred embodiment dedicated for the GSM 900 MHz band and the 1800 MHz band, respectively.

#### The radiating element in the 900 MHz band.

[0024] The surface currents on the radiating element 48 in the 900 MHz band starts from the feeding point 42 and continues along a broad passage (common frequency part 39) having a rounding 52 which allows the surface current (illustrated by arrows A) to whirl easily around the bottom 53 of the slit 46. Hereby the distribution of the surface currents becomes more evenly distributed compared to an embodiment having this passage provided with straight parallel edges. It has been observed that this rounding 52 increases the gain of the radiating element 48 in the direction normal to the

radiation element.

[0025] At the end of the slit 46 there is provided a capacitive coupling 58 (fig. 6) with the ground plane. This coupling 58 reduces the GSM 900 MHz resonance frequency. When the distance between the termination of the metallic layer and the ground plane is decreased, the capacitive coupling 58 is increased and thereby the GSM 900 MHz resonance frequency is lowered.

[0026] The circumference and thereby the length of the GSM 900 MHz resonator element 48 is determining for the GSM 900 MHz resonance frequency. This circumference of the GSM 900 MHz resonator element 48 does not affect the gain of this element.

[0027] The longer the tip 59 of the resonator element 48 is, the lower the 900 MHz resonance frequency will be. However the tip 59 must not come too close to the point 60 on the 1800 MHz resonator element 49 near the opening of the slit 46 because this will increase the coupling between the two radiating elements and the grounding point adjacent to the opening of the slit 46. If the coupling to ground from the tip 59 is increased the gain of the 900 MHz resonator element 48 will become decreased.

[0028] It has been observed that a constant width of the slit 46 and a broad ending (the width is increased towards the end) of the 900 MHz resonator element 48 gives the highest gain figures.

[0029] The length and in particular the circumference of the slit 46 has a substantial influence on the 900 MHz resonance frequency - the longer the slit 46 is, the lower the resonance frequency will be.

[0030] The width of the slit determines both the resonance frequency and the gain. A thinner slit 46 gives a higher 900 MHz resonance frequency (partly due to the fact that the circumference is shorter, partly due to the negative coupling of opposite currents) as well as a lower overall gain (due to the negative coupling of the currents running along the two sides of the slit 46).

[0031] Normally the slit 46 will be designed for maximum gain. However it has been observed that a wide slit 46 results in a low resonance frequency and in a slightly lower gain. This might be due to the fact that the minimum width of the resonator element 48 is reduced in order to maintain the overall size of the antenna body. This will affect the ability of the resonator element 48 to guide the surface currents in an effective manner. However the width of the resonator element 48 may then be increased by letting the element 48 have an extension 68 wrapping around the smooth edge of the antenna body. This will lower the resonance frequency of the element 48 due to the increase in circumference, but the gain will be reduced, too. The gain reduction is caused by the fact that the electromagnetic field is kept inside the structure.

[0032] Terminating the slit 46 in a bend portion 66 as shown in fig. 8 may increase the resonance frequency. The angle between the main portion 46 and the bend portion 66 will preferably be around 90° symbol 176

If "Symbol" is 12°.

[0033] Alternatively the slit 46 is continued as a downwardly extending portion 67 into the capacitive coupler 58 as shown in fig. 9. This will reduce the overall gain of the 900 MHz band.

#### The radiating element in the 1800 MHz band.

[0034] The surface currents on the radiating element 49 in the 1800 MHz band starts from the feeding point 42 and passes the common frequency part 39 around the end of the second slit 47. The second slit 47 increases the bandwidth in the GSM 900 MHz band and reduces the bandwidth in the GSM 1800 MHz band. However it has been observed that the improvement of the bandwidth in the lower frequency band is higher than the bandwidth reduction in the higher frequency band. It is believed that this is due to the fact that the surface currents have to run in a quite diffuse way - see the arrows B in fig. 7 - and thus resulting in paths having different lengths, which causes the resonator element 49 to resonate at different frequencies in a continuous frequency band.

[0035] The width of this slit 47 has an impact on the bandwidth in the GSM 1800 MHz band. The wider the slit 47 is the lower the bandwidth of the upper frequency band will be. At the same time a wide slit will reduce the gain of the GSM 900 MHz band resonating element 48. Therefore the slit will be provided with a minimum width in the range 0.8 mm and with a length in the range 4.2 mm. This minimum width ensures a minimum coupling between the two resonator elements 48 and 49 and is mainly determined by the manufacturing process where a shot moulding process is used according to the preferred embodiment. The length of the slit 47 determines the bandwidth of the 900 MHz band and the gain of the 1800 MHz band. The longer the slit 47 is the higher the bandwidth in the 900 MHz band will be, and the lower the gain in the 1800 MHz band will be.

[0036] A cut 61 decouples the two frequency bands by forcing the 900 MHz current not to run on a capacitive 1800 MHz coupler 54. Reducing the width of the metal pattern between the end of the slit 47 and the cut 61 will have the same effect as increasing the width of the slit 47.

[0037] The 1800 MHz band resonating element 49 is terminated in a shorting surface 56 which is biased toward the shield 24 acting as ground plane for the antenna. A metalized pin 51 lowers the resonance frequency of the 1800 MHz band and is moreover used as a gripping arm for attaching the antenna to the shield 24/PCB 21. The reason for the resonance frequency lowering is that the surface currents (the arrow C in fig. 6 and 7) can pass around the pin 51 before coming to ground on the rear side of the shield 24 and thus run a longer electrical distance.

[0038] Another pin 57 similar to the pin 51 is provided for fixing the antenna to the shield 24. However

the pin 57 is not metalised and only serves a mechanical purpose. In both sides of the antenna body there is provided protrusions 55 for establishing snap connection to the shield 24 having similar recesses 65.

[0039] With reference to fig. 6 it is seen that the capacitive coupler 54 is provided as a metallic pattern part on a wall extending towards the shield 24. This coupler 54 reduces the 1800 MHz band resonance frequency - the closer to the ground plane the pattern is terminated the higher coupling there will be and this causes a lower resonance frequency.

#### The antenna body.

[0040] Basically the antenna body 40 as shown in perspective view in fig. 6 and 7, is provided as plastic body in a two shot moulding process. According to the preferred embodiment of the invention the plastic materials used for the two shots needs to have basically specified characteristics - primarily with regard to electrical properties of the antenna body. Advantageously the plastic material or the dielectric material for internal antenna is selected as being a crystalline polymer synthesized from styrene monomer. A surface of such a plastic body may not be coated (plated) with metal while a surface of the same plastic but provided as a compound with an appropriate catalyst may be plated.

[0041] The metallic material will adhere to the compound plastic only and a pattern useful as the strip lines for the antenna may be created. Idemitsu Petrochemical Co., Ltd. markets a dielectric material useful for the manufacturing of the antenna body 40 under the trade name XAREC®.

[0042] According to the preferred embodiment two variants Xarec S-131 (GF 30%) and Xarec SP-150 (GF 30%) are used for the first and second shot, respectively. The preferred dielectric material is syndiotactic polystyrene (SPS). Alternative materials having similar properties may be used, e. g. Questra QA 802 or Catalyzed SPS RTP 4699 x 79007.

[0043] The required characteristics for the material in order to be used in an antenna is appropriate electrical properties, such as dielectric constant and loss factor, and an ability to keep these properties for a long time. Basically this requires that the water absorption rate is low in order to secure that the dielectric properties of the antenna remain substantially at the same level. Otherwise the absorbed water will affect the dielectric properties of the antenna body. Xarec S-131 (GF 30%) and Xarec SP-150 (GF 30%) have a water absorption/24h at 0,05 % according to the ASTM D 570 test method.

[0044] Basically the properties of these dielectric materials may be found from the associated data sheets. However the materials have been selected primarily due to their dielectric constant in the range 3.0-3.1 which affects the relationship between the resonance wave length and the wavelength in free air. Fur-

thermore the water absorption rate is very important because the presence of water in the dielectric material will greatly affect the dielectric properties thereof.

#### The preferred method for manufacturing the antenna.

[0045] According to the preferred embodiment of the invention a method for manufacturing the antenna body 40 as described above will comprise steps of injection moulding followed by plating steps for establishing the required metallic pattern.

[0046] Fig. 14 (a) illustrates the basic steps in the injection moulding process. As a first step the cavity is created in between a first and a second mould part, 101 and 102 respectively. This cavity is created by moving a first tool 120 towards a second tool 121 as shown by the arrow A. The first tool 120 has a two identical mold parts (second mold parts 102 and 106), and the second tool 121 has three mold parts (a third mold part 103 and two first mold parts 101 and 105 adjacent thereto). The resin is shot (first shot) into the cavity created by the first mold part 101 and the second mold part 102 whereby a first body part 100 is created (the geometrical form of the body is simplified in fig.14 (a) and (b) compared with the actual form shown in fig. 11 and fig. 12). The resin used for this shot repels metal in a later metalization process. The resin is injected through an inlet 104 provided in the first mould part 101.

[0047] Then the two tools 120 and 121 are separated as indicated by the arrow B in fig.14(b), and the first body part 100 is maintained in the second mould part 102. The tool 120 is then displaced so that the second mould part 102 becomes aligned with the central third mould part 103. The tools 102 and 103 will form a cavity having the form of the final antenna body part 40 shown in fig. 6 and 7. However the first body part 100 fills a substantial part of this cavity whereby the residual cavity for receiving the second resin corresponds to the body part 110. The tools with the cavity in which the first body part 100 is placed is pre-heated whereby the second resin when shot into the cavity integrates with the first resin body to form a coherent antenna body. This coherent body is given the reference number 112. The resin used for the second shot allows metal to adhere in a later metalisation process. The resin is injected through an inlet 104 provided in the third mould part 103.

[0048] In plating the plating process, e.g. an electroless dip process, a 10-12  $\mu\text{m}$  Cu-plating is added to the surface of an antenna body in a pattern defined by the two mould shots. The Cu-layer is finally protected by a thin Ni-layer having a thickness around 1-2  $\mu\text{m}$ . The Ni-layer protects the current carrying Cu-layer. Finally the part is dipped in a chromate solution in order to passivate the Nickel surface. The metal only adheres to the resin used in the second shot of the injection mold process.

[0049] By using this lateral displacement of the tool 120 the first resin is shot into cavity partly defined by one of the second mould parts 102 at the same time as the second resin is shot into cavity partly defined by other of the second mould parts 106. Then the first resin is provided through the outlet 104 in one of the first mould parts 101 and 105, while the second resin is provided through the outlet 104 in the third mould part 103. Only one of the first mould parts 101 and 105 that is aligned with one of the second mould parts 102 and 106 injects resin during a shoot.

#### Size of the dielectric body.

[0050] The antenna body described with reference to fig. 3-11 is designed as a dual band antenna for the GSM 900 MHz band and the GSM 1800 MHz band has in the preferred embodiment an overall width around 45 mm, an overall height around 37 mm and overall thickness around 9 mm. The overall length of the GSM 900 path 48 is 50-55 mm. The overall length of the GSM 1800 MHz path 49 is 20-30 mm.

#### Radiation pattern.

[0051] Fig. 12 and 13 illustrates the radiation pattern for the 900 MHz band and 1800 MHz band, respectively. The  $S_{11}$  minimum return loss has been measured to -17 dB for the GSM 900 MHz band and to -34 dB for the GSM 1800 MHz band. The bandwidth at  $S_{11} = -6$  dB is 78 MHz (8 MHz excess) for the GSM 900 MHz band and 180 MHz (10 MHz excess) for the GSM 1800 MHz band, respectively.

[0052] The maximum gain is 1.6 dBi for the GSM 900 MHz band and 5.2 dBi for the GSM 1800 MHz band, respectively. The maximum gain at band edges is 0.8 dBi for the GSM 900 MHz band and 3.23 dBi for the GSM 1800 MHz band, respectively. The estimated efficiency at centers is 70 % for the GSM 900 MHz band and 60 % for the GSM 1800 MHz band, respectively. The center frequencies are 925 MHz and 1795 MHz, respectively.

[0053] Fig. 12 shows that the power radiated in the GSM 900 MHz band through the rear side of the phone is 1.6 dBi, while the power radiated in the opposite direction is at least 1.6 dB lower. Fig. 13 shows that the power radiated in the GSM 1800 MHz band through the rear side of the phone is 5.2 dBi, while the power radiated in the opposite direction is almost negligible.

#### Claims

1. An antenna device having:

- a first metallic layer acting as resonator plane and defining at least two radiating elements separated by a first slit;
- a second metallic layer arranged substantially

- in parallel with the first metallic layer and acting as ground plane for the antenna device;
- feeding means connected to said first and the second metallic layer for feeding an RF signal to the antenna device, said feeding means includes a feeding point in the first metallic layer,
  - said first metallic layer is provided with a second slit extending from said first slit with the feeding point placed on a metallised tongue between the first and the second slit, whereby surface currents have to pass around the tips of the slits towards the radiating elements.
2. An antenna device according to claim 1, wherein a capacitive coupling is provided between one of said two radiating elements and said second metallic layer.
  3. An antenna device according to claim 2, wherein the capacitive coupling is provided adjacent to a neck of the pattern, the said end of the second slit and a cut adjacent to the capacitive coupling defines neck.
  4. An antenna device according to claims 2 or 3, wherein the capacitive coupling is provided as a metallic coating extending perpendicular to said first and second metallic layers, and is terminated a short distance from one of said first and second metallic layers compared to the distance between said first and second metallic layers.
  5. An antenna device according to claim 1, wherein the first metallic layer acting is coated onto a dielectric body.
  6. An antenna device according to claim 5, wherein the dielectric body is provided by an injection moulding process including two shots.
  7. An antenna device according to claim 6, wherein the material used in one of the two injection moulding shots is a resin repelling metal in a subsequent coating process, and wherein the material used in the second shot is a resin to which metal in the subsequent coating process adheres.
  8. An antenna device according to claim 5, wherein the dielectric body is provided with coupling means for establishing a releasable interconnection with a separate metal body acting as the second metallic layer of the device.
  9. An antenna device according to claims 5-8, wherein the feeding means includes a bore through the dielectric body as a connection via connecting the first metallic layer to a connection pad on the rear side of the dielectric body.
  10. An antenna device according to claims 2-9, wherein the capacitive coupling between said first and said second metallic layers by locally reducing the distance between said first metallic layer and said second metallic layer, and by providing a metallic coating extending perpendicular to said first and second metallic layers, and is terminating this coating in a short distance from one of said first and second metallic layers compared to the distance between said first and second metallic layers.
  11. An antenna device according to claim 10, wherein dielectric body is releasable interconnection with a separate metal body acting as the second metallic layer of the device, and wherein the metal body is provided with a stepwise raised part to establish the capacitive coupling.
  12. A hand portable phone having an internal antenna including:
    - an antenna device having:
      - a dielectric body;
      - a metallic layer provided on said dielectric body and acting as resonator plane and defining at least two radiating elements separated by a first slit;
      - said metallic layer is provided with a second slit extending from said first slit with the feeding point placed on a metallized tongue between the first and the second slit, whereby surface currents have to pass around the tips of the slits towards the radiating elements;
      - a metallic shield part covering at least a part of a printed circuit board of the phone and arranged substantially in parallel with the metallic layer on dielectric body and acting as ground plane for the antenna device; and
      - feeding means provided on the printed circuit board and connected to said metallic shield part and the metallic layer provided on said dielectric body for feeding an RF signal to the antenna device.
  13. A hand portable phone according to claim 12, wherein the dielectric body is provided with coupling means for establishing a releasable interconnection with metallic shield part.
  14. A hand portable phone according to claims 12 or 13, wherein the feeding means includes a bore through the dielectric body as a connection via connecting the metallic layer to a connection pad on the

rear side of the dielectric body.

5

10

15

20

25

30

35

40

45

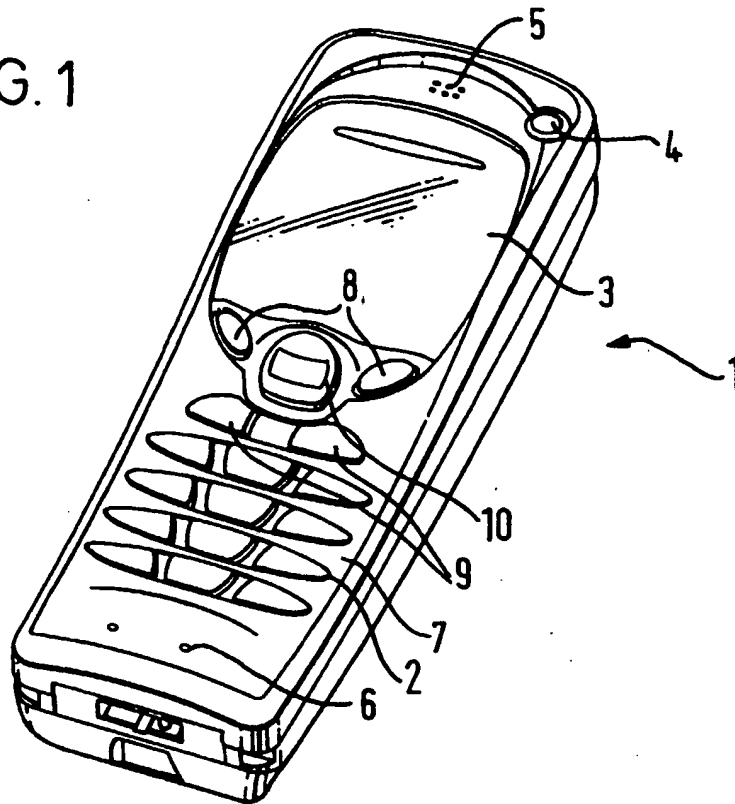
50

55

8



FIG. 1



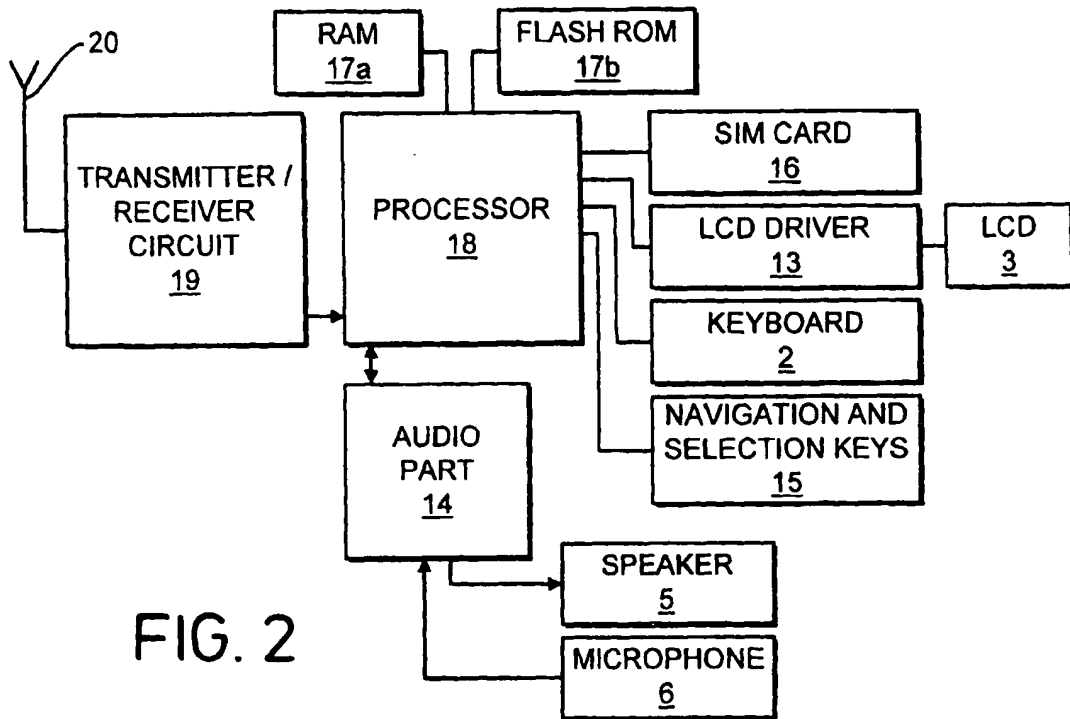


FIG. 2

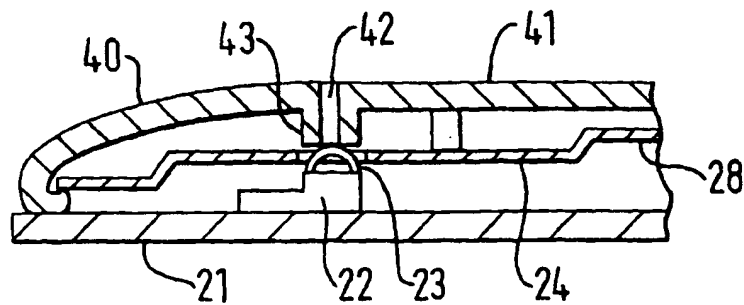
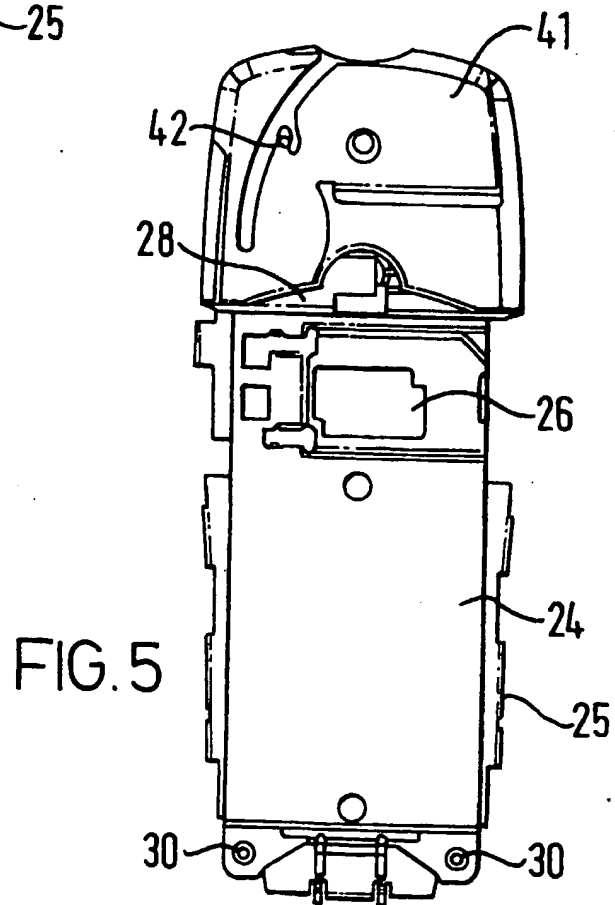
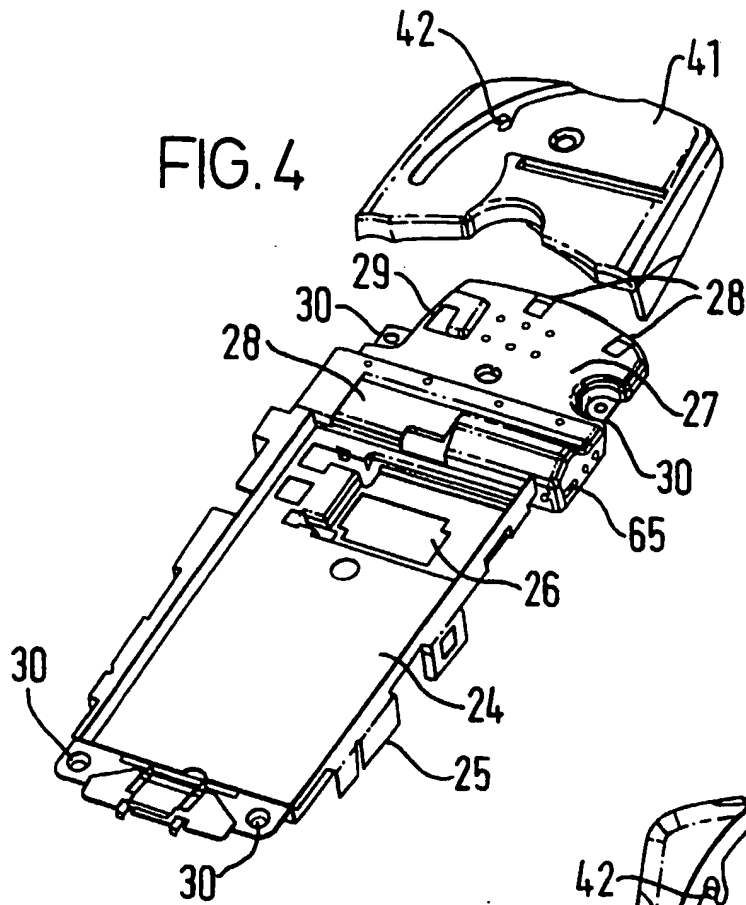
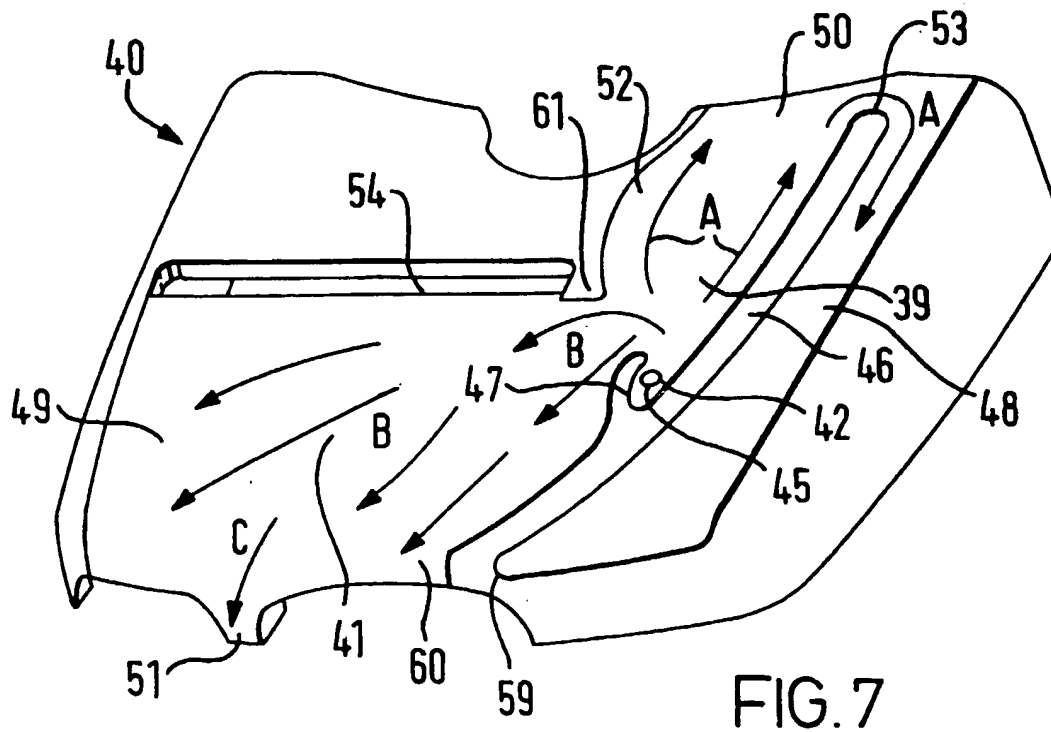
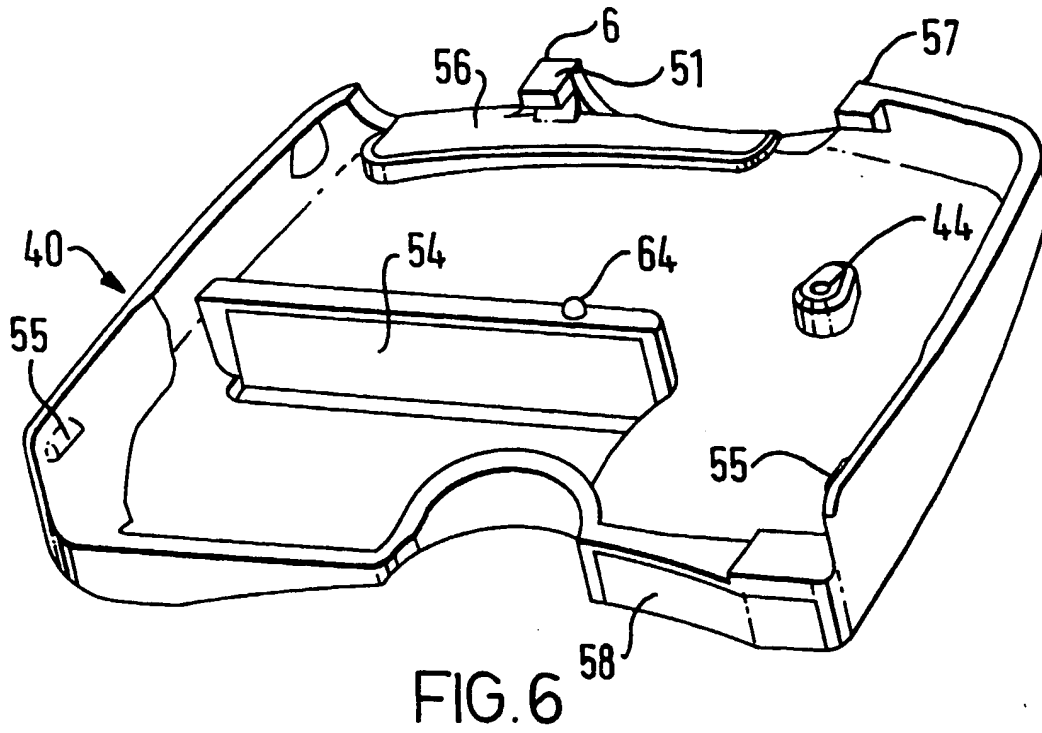
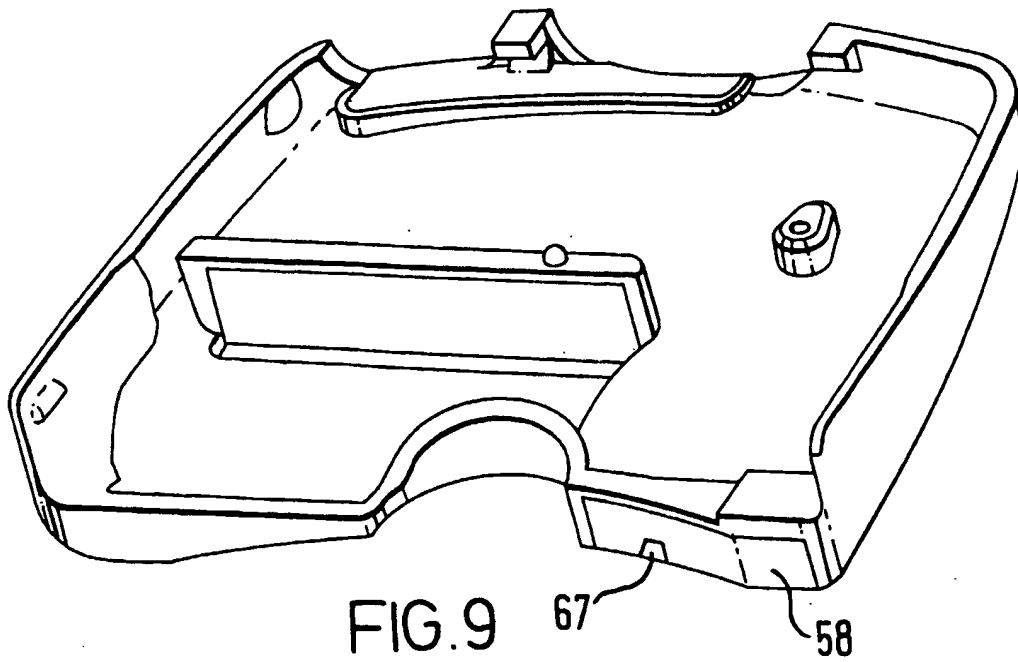
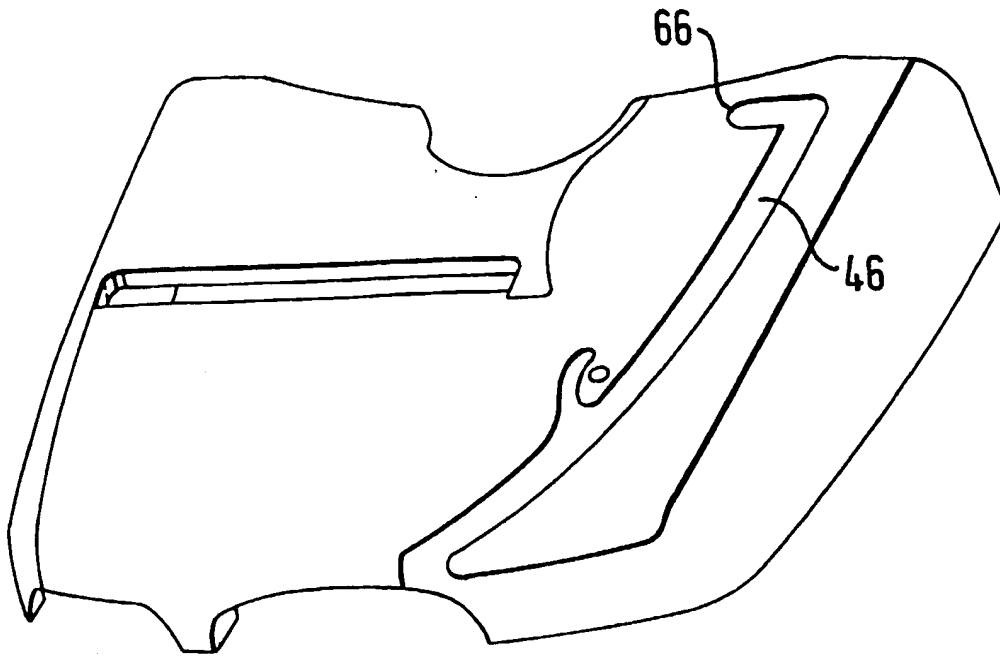


FIG. 3







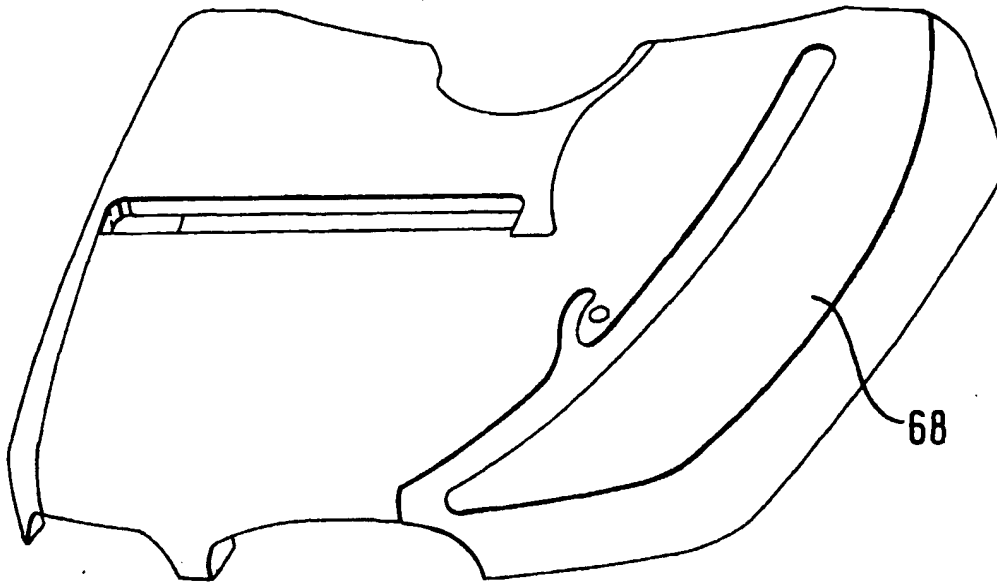


FIG. 10

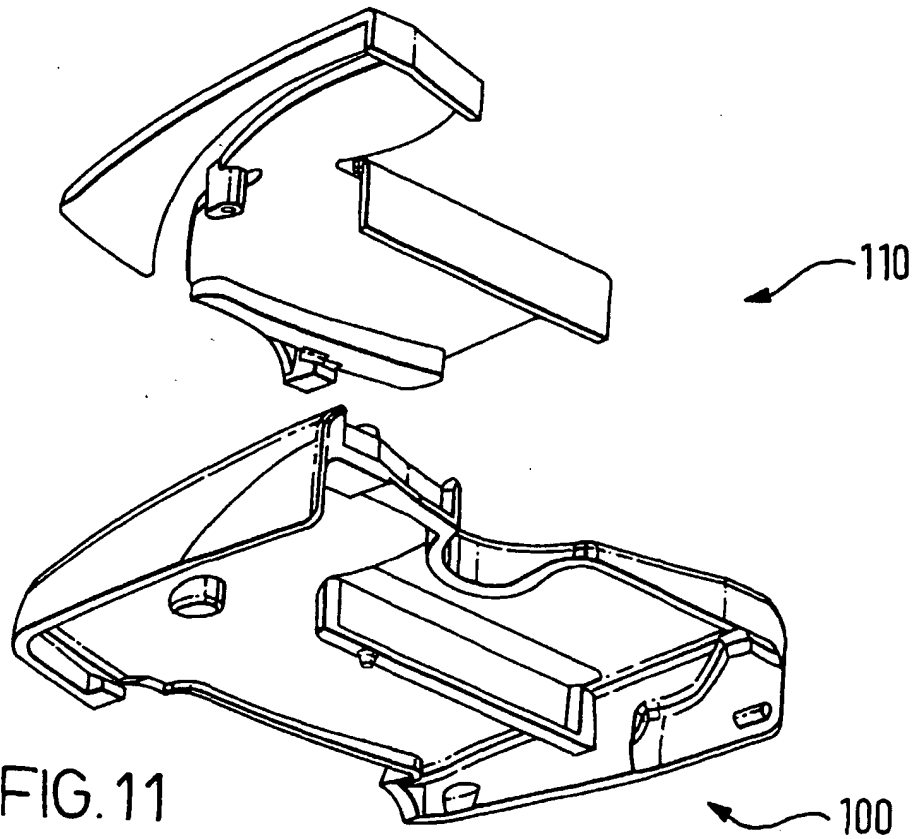


FIG. 11

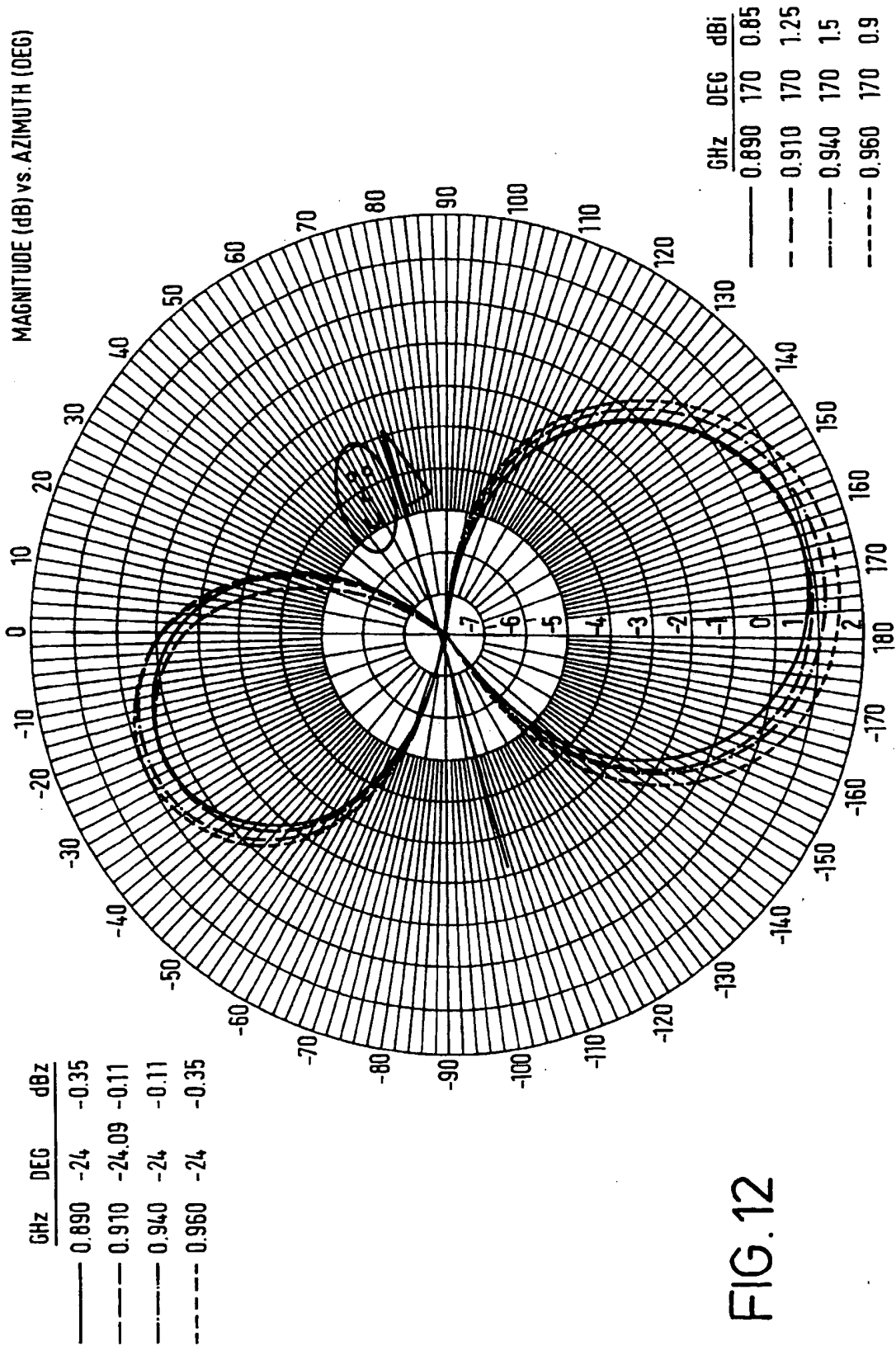
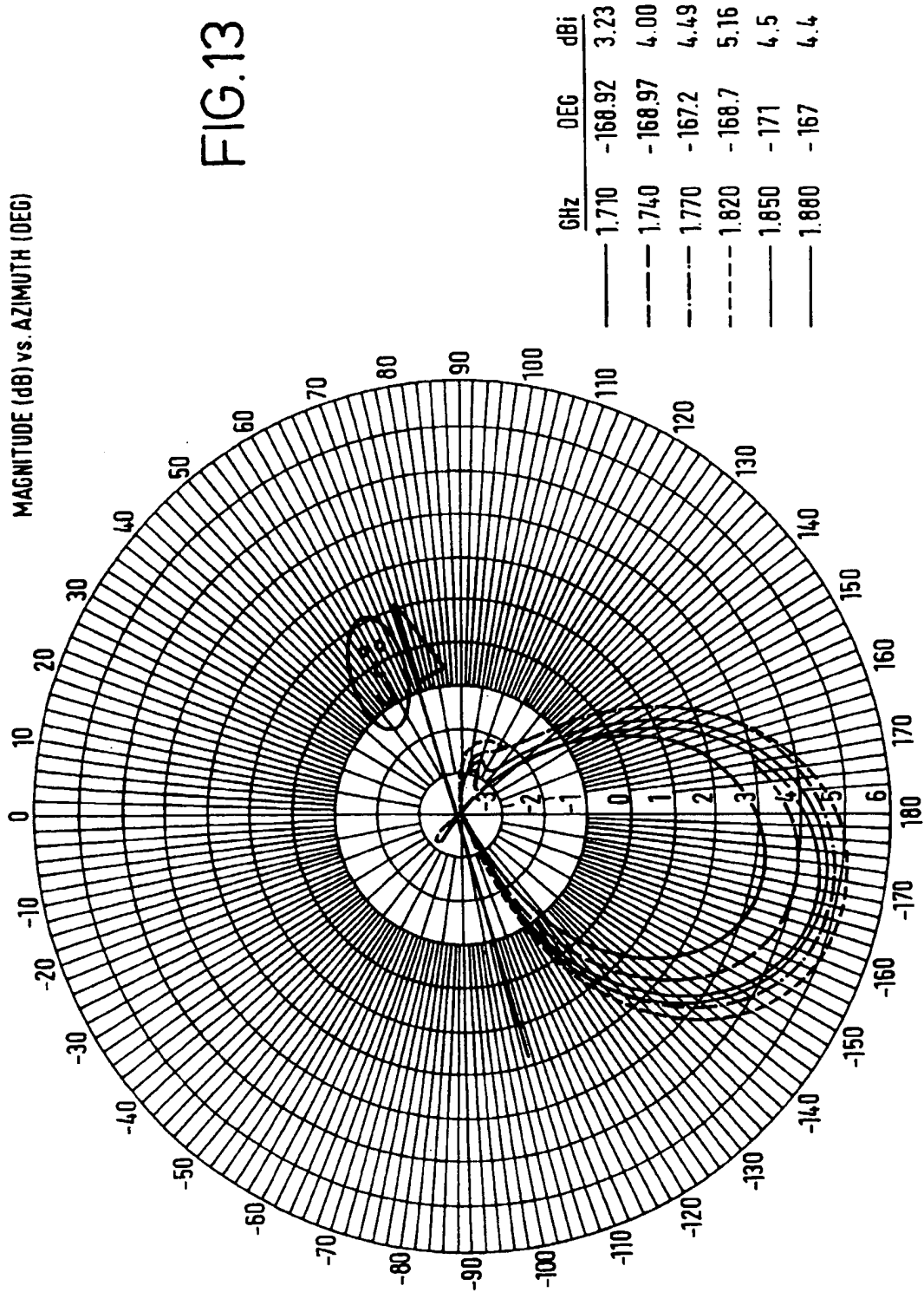


FIG. 12





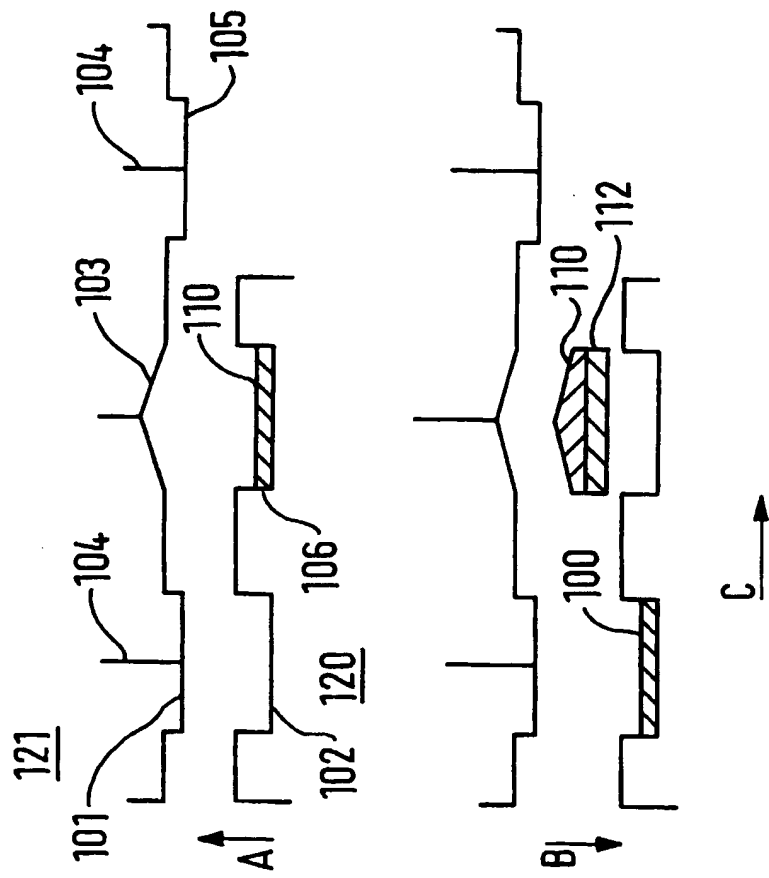


FIG. 14

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**